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THE GEOLOGY OF THE SOUTHERN UPLANDS OF SCOTLAND.

The Silurian Rocks of Britain. Vol. I. Scotland. By B. N. Peach, F.R.S., and J. Horne, F.R.S.E.; with Petrological Chapters and Notes by J. J. H. Teall, M.A., F.R.S. Pp. xviii+749; plates xxvii, and a coloured map. (Memoirs of the Geological Survey of the United Kingdom, 1899.)

THE student of historical geology, in his endeavour to obtain a comprehensive view of the sequence of events in a particular area, is too frequently conscious that he is gazing at a distorted picture. It is probably beyond the power of any one person to gather together the tangled mass of detail, and by a process of anamorphosis, to illustrate the geology of even a single country in such a manner that while the proportions of the whole work are harmonious, every important detail is also presented with conspicuous clearness. But that which is too much for one person may be carried out by a band of workers under the direction of one chief; and fortunately we in Britain, the mother-country of stratigraphical geology, not only possess this band, but know that it is actually engaged in the accomplishment of the desired work.

It is now some years since the first volume of a series of memoirs devoted to a detailed study of the various great groups of the British stratigraphical rock-column was issued by H.M. Geological Survey. This series, when complete, will place within reach of the geologist a history of the British strata, of which we cannot overestimate the value. The Jurassic rocks of Britain have already been described in two volumes: one, by Mr. Fox-Strangways, treating of the Jurassic rocks of Yorkshire; the other, by Mr. H. B. Woodward, describing those of the other British areas. Another volume, by Mr. Clement Reid, is devoted to the Pliocene strata, and we are now presented with the first volume of the series in which the British Silurian rocks will be described, the particular volume under consideration containing an account of the Silurian rocks of Scotland.

The most important area of Silurian rocks in Scotland is developed in the Southern Uplands, and to consideration of this area the present volume is essentially confined. It is noted, however, that igneous rocks and radiolarian cherts have been detected along the southern border of the Eastern Highlands; and in this connection it is interesting to note that Hugh Miller in his "Rambles of a Geologist" records, on the authority of Dr. Emslie, the occurrence of graptolites in a slate quarry at Gamrie Head, near Banff.

In glancing at the memoir by Messrs. Peach, Horne and Teall, we are at once struck with the fact that the great bulk of the contents consists of records of fresh observations. The amount of work which the authors have performed in the field and the laboratory is surprising even to the general reader, still more so to any one who from some knowledge of the area is cognisant of its extraordinary complexity.

Great as the amount of new work recorded in this volume

undoubtedly is, the authors took up their study of the region subsequently to its description by a number of other geologists, of whom the illustrious Hutton was the first, while Prof. Lapworth, as is well known, reduced the stratigraphy of the area to order in several masterly papers appearing in the *Quarterly Journal of the Geological Society*, the *Geological Magazine*, and the *Annals and Magazine of Natural History*. The importance of Prof. Lapworth's work is acknowledged in the volume under notice, in the fullest manner, both in the chapter devoted to the history of previous researches in the south of Scotland and in those which treat of the geology of the region in detail.

Though Lapworth led the way to appreciation of the complicated nature of the geology, the authors of the memoir have not only verified his conclusions, but added a great deal of confirmatory matter, and have furthermore made a series of discoveries which throw light upon questions of prime importance to geologists.

Among the discoveries which are of general interest as shedding light upon geological matters of widespread importance, we may notice the discovery of Arenig graptolitic mudstones, radiolarian cherts and contemporaneous volcanic rocks over very wide tracts of country in the Southern Uplands and South-eastern Highlands; the detection of the occurrence of further volcanic outbursts in Llandeilo and Caradoc times; the evidences of the lateral variations in the sediments of different ages indicating a source of supply of terrigenous sediment to the north-west of the area, and of the gradual encroachment of the coarser sediments to the south-east, in the later periods of Silurian times; the definition of a Downtonian period between Ludlow and Old Red Sandstone times, and the description of the rocks of this period; and the discovery of a remarkable fauna of fishes in these Downtonian strata, which has been described by Dr. Traquair. The above discoveries are mainly due to Messrs. Peach and Horne, who, like Lapworth, have chiefly utilised the graptolites as a means of comparing the strata of different localities, though they have also obtained much assistance from the persistent cherts, which, as shown many years ago by Dr. G. J. Hinde, were largely formed by the accumulation of tests of radiolaria. The writers appear to adopt the suggestion that these radiolarian cherts are deep-water deposits, though, in consideration of the evidence which they adduce in support of the existence of a tract of land at no great distance to the north-west, it seems doubtful whether the cherts are strictly comparable with the abyssal radiolarian oozes of modern oceans. Mr. Teall gives a petrographical account of the remarkable volcanic rocks associated with the radiolarian cherts, and of the contemporaneous volcanic rocks of higher strata; also a description of the intrusive rocks of the Girvan and Galloway district, with details of the nature of the metamorphism impressed upon the rocks surrounding the irruptive igneous masses. One exceedingly significant suggestion is made to the effect that the coarsely crystalline plutonic rocks were consolidated beneath a small thickness of overlying rock-cover, though it is stated that the evidence for this is imperfect.

The results of the palæontological investigations are

summarised in lists of fossils, occupying about fifty pages at the end of the work; these, and the detailed lists of fossils appearing throughout the book, will be of the utmost value to the stratigraphical palæontologist.

The form in which the book is presented to the reader is excellent, and the work is well illustrated. In addition to the numerous diagrams and sections illustrative of the geology of the area, which are scattered through the memoir, there are seventeen plates reproduced from photographs illustrating the appearance of some of the sediments, including the radiolarian cherts, and especially of the volcanic rocks, both lavas and fragmental accumulations; in connection with the lavas, we may particularly note the illustrations of the remarkable rocks with "pillow-form" structure which are associated with the radiolarian cherts. Of the remaining plates, eight represent microscopic sections of various rocks, while two are devoted to illustrations of characteristic graptolites. In addition to these plates, there is a well-coloured geological map of the area, on the scale of ten miles to the inch.

The third chapter of the book, in which the authors give a general description of the Silurian rocks of the Southern Uplands, will be read by all geologists; the detailed descriptions in the other chapters will be largely utilised by those who visit the region; and, if we mistake not, these visitors will in future become very numerous, attracted to the district owing to the publication of a memoir upon a region of exceptional complexity but also of exceptional interest—a memoir which will at once take its place as a classic in geological literature. J. E. M.

THE PHILOSOPHY OF ATOMIC THEORIES.

Essai critique sur l'Hypothèse des Atomes dans la Science contemporaine. Par Arthur Hannequin, Professeur à la Faculté des Lettres de l'Université de Lyon. Second edition. Pp. 457. (Paris: Alcan, 1899.)

PROF. HANNEQUIN attempts, in the first of the two books into which his work is divided, by a discussion of the first principles of mathematical knowledge and a study of the progress of physical and chemical science, to establish at once the necessity and the contradictions of atomism; in the second book it is sought to reconcile the contradictions by an appeal to metaphysics.

According to M. Hannequin it is by a necessity of its nature that human science reduces all to the atom as it has already reduced all to motion—the need to render intelligible all that falls under the intuition of the senses or all phenomena. Our mind can only take hold of or comprehend what comes from itself, it only knows fully what it creates. Thus science in the measure of its rigour and certainty is a creation of our mind. The science *par excellence*, the science derived entirely from the mind is the science of number. Physical atomism is not imposed on science by reality, but by our method and by the nature of our knowledge. It does not necessarily imply the real discontinuity of matter; it implies only that we make it discontinuous in order to comprehend it. It has its origin in the universal use of number.

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"The atom is found at the end of all analysis as the product of the struggle of quantity against magnitude, of unity and number against the multiplicity and continuity of space and time."

In Chapter i. of the first book M. Hannequin discusses the question whether pure geometry itself involves the notion of quantity, and therefore of number, and concludes that it does. Analytical geometry more obviously does so, and the author discusses at some length what is involved in the process of differentiation. Infinitesimal analysis appears to him to lead the mind necessarily to postulate in every geometrical object indivisible elements. On the other hand he concludes that all attempts, such as that of Cantor, which is criticised at some length, to express continuity by means of number must fail.

The analysis which gives us the concept of the geometrical element would not of itself, according to M. Hannequin, have given us that of the atom, had not our mind demanded the mathematical explanation of nature.

With mechanics our mathematics approaches as closely as it can phenomena and reality. In Chapter ii., on "Atomism and Mechanics," the author sets out to show that our ideas of motion lead us straight to the discontinuity of matter. His treatment of the fundamental notions of mechanics, of motion, force, mass, is interesting but not always convincing. For instance, it scarcely seems legitimate to make the first law self-evident by saying that when a body is in a state of uniform rectilinear motion or is at rest, one has the right to affirm by definition that it persists in an identical state, and that to no change corresponds no cause; on the other hand, to every definite variation of velocity or to every acceleration must correspond a definite cause which we call a force.

The hypotheses of centres of force, such as that of Boscowich, are condemned by Hannequin on what appear to be inadequate grounds. Vortex rings meet with no better fate.

When we come to "kinetic atomism" the necessity of postulating atoms becomes more apparent than the author has thus far succeeded in making it, and at the same time contradictions also appear. The difficulties of kinetic atomism as brought out by M. Hannequin are twofold. In the first place, we have the contradiction between the indivisibility of the atom and its perfect elasticity. In the second place, the number of atoms can neither be infinite nor finite. It is apparently atomism of the most thorough-going kind that is here considered, action at a distance being excluded and gravitational energy being taken as kinetic; otherwise there is no difficulty in holding the number of atoms to be finite.

In Chapter iii., on atomism and nature, the author attempts to show that the particular sciences of nature arrive at atoms of different and decreasing orders.

The chemical atom is first considered; the laws of definite and multiple proportions, and the methods of determining the relative masses of the atoms with the aid of Avogadro's and Dulong and Petit's laws being discussed. The possibility of the existence within the chemical atoms of smaller primordial atoms is next treated with reference to Prout's hypothesis and the facts of thermal chemistry and chemical affinity.